The Victorian Naturalist

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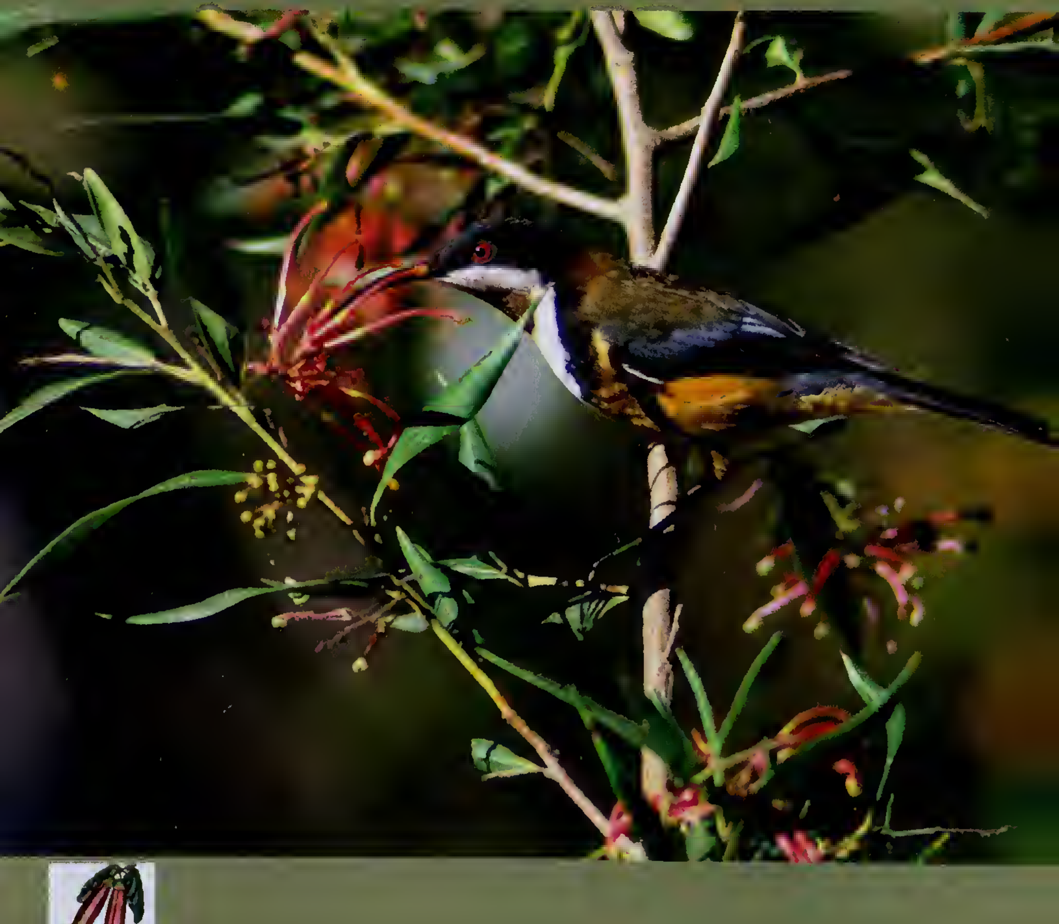

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From the Editors

We begin this new volume of the journal with an issue that is typical of its kind. Although slim in size, this issue is diverse in content. We start the year with reports on work in four different fields within natural history, focusing attention on a pest avian species; clonal and non-clonal wetland plants; leaf litter invertebrates in box-ironbark forest; and an amphibian species that has survived against the odds. Truly, there is something here for most interests.

Looking ahead for the year, we anticipate no great change to our usual fare. We are encouraged in the belief that there are researchers interested in the widest range of natural history areas and at work in many different environments. We thus feel confident there will be no end to the papers offered for publication.

Changes are occurring, however. Perceptive readers will have noticed that more colour has been added to the front and back covers of this issue. This new appearance is really an expansion of the previous format, taking advantage of the fact that the cover is already presented in colour. Curiously, this new style of cover is vaguely reminiscent of the style introduced with volume 88, no. 1, January 1971. Much has changed since then, for the Field Naturalists Club and for its journal, and this is not necessarily to be regretted. As the Sicilian novelist Guiseppe di Lampedusa observed: 'For things to remain the same, things must change'.

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The

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Front cover: Eastern Spinebill *Acanthorhychus tenuirostris*. Photo by Dan Carey Photography
Back cover: Box-ironbark country – Warby Ranges, looking across Lake Mokoan. Photo by Joyce Annear, from FNCV Archives.

Eliminating an avian pest (House Sparrow *Passer domesticus*) population: the role of trapping at a homestead scale

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Abstract

In the absence of Australian data about methods to control House Sparrows *Passer domesticus* this paper investigates the role of harbour removal and trapping to eliminate a House Sparrow infestation from a farm property near Mansfield, Victoria. Over 23 years, 630 House Sparrows were captured and the property has had no resident sparrows for 13 years. Benefits from the removal of House Sparrows are listed. Over the past 10 years, records of captured dispersing House Sparrows from other locations indicate that 85% of these birds arrived during summer and less than 1% during mid-winter to late spring. Once resident sparrow numbers were reduced to zero, birds arriving appeared nervous and usually dispersed before the trap was set. Based on this work, trapping is most effective during the dispersal period. These findings should encourage others to view House Sparrows as pests that can be eliminated with judicious trapping (care, skill and observation) and the removal of harbors. It is proposed that the effective use of trapping over a catchment scale based on homestead action should be able to reduce or eliminate House Sparrows from Australia. (*The Victorian Naturalist* **125** (1), 2008, 4-10)

Introduction

The House Sparrow *Passer domesticus* is a native bird of northern Africa and Eurasia that has been introduced to the Americas and Australia (Blakers *et al.* 1984). In North America, the House Sparrow was one of eight species with the highest ranking of 48 potential exotic pests evaluated for invasive potential (Smallwood and Salmon 1992). The speed of colonisation has been measured at up to 105 km/year in Australia (Barrett *et al.* 2003) and island hopping in the Caribbean (Clergeau *et al.* 2004) and Norway (Jensen *et al.* 2004) could be of similar magnitude. While House Sparrows are known agricultural pests that cause damage to grain crops, poultry rations, storage sheds, livestock feedlots, fruit trees, sprouting vegetables and amenity flowers, they also compete with native birds for food, and spread diseases and parasites (Bryant 2002, Kern 2003, McInerney 2004).

House Sparrows were introduced to Australia in about 1861 (Gillbank 2001) and in 1872-1874 the Cincinnati Acclimatization Society introduced House Sparrows into the USA (Bryant 2002). In Australia, House Sparrows significantly increased the area they occupied during the twentieth century (Blakers *et al.* 1984) and now occupy about one half of the Australian land area (Barrett *et al.* 2003). House Sparrows are now so conspicuous that they ranked 31st on the list of most frequently reported species in the recent Atlas of Australian Birds (Barrett *et al.* 2003). Over recent decades the ecology of House Sparrows and the impact of and problems caused by House Sparrows in Australia have rarely been discussed.

Rolls (1984) states that by 1876 it was realised that it had been a mistake to introduce House Sparrows into Australia. They had become such a nuisance that 'clubs had been formed in Victoria for their destruction, and rewards were offered for both eggs and dead birds'. It is no wonder then that a Farmers Handbook (Anon 1934, 1978), reports that many people used traps and poisoning to reduce sparrow numbers. This Handbook provided plans for a sparrow trap and advised that 'sparrow traps of similar design have given great satisfaction'. However, this claim is unsubstantiated and has been questioned by the government department responsible for fauna conservation: 'Needless to say, it hasn't proven very effective in controlling the sparrow population' (Anon 1995). It appears that Australian wildlife and ecological specialists in the tropics hold the view that poisoning is the only method to

control sparrows, as Harrison and Congdon (2002) concluded that the close association of House Sparrows with human settlements, the difficulty of control and the probable detrimental effects of control measures (poison) on urban native species, means that the overall pest status of this species was unlikely to change. Neither Anon (1995) nor Harrison and Congdon (2002) provide any evidence that trapping is unsuccessful or that poisoning is safe.

Donlan *et al.* (2003) reviewed scientific articles published between 1991 and 2002 on the eradication of invasive exotic species and found no articles dealing with research on eradication techniques. They concluded that the bias in the literature is impeding conservation action against the effects of invasive species and called for four actions to overcome this bias including evaluating existing tools for invasive-species eradication. According to Donlan *et al.* (2003), while there are significant examples demonstrating the value of eradicating invasive species, the use of eradication as a technique remains on the fringe of conservation circles, and they call for further development of this powerful tool by the publishing of supporting research. This call has been echoed by Cruz *et al.* (2005).

Given House Sparrows are highly invasive and there is a lack of objective information concerning their removal, particularly efficacy of trapping, here we report on the operation and effectiveness of trapping as a control measure. This article also provides some details of House Sparrow dispersal in south-eastern Australian farmland.

Methods

The aim of this work was to eliminate House Sparrows from a farm property in south-eastern Australia. The 65 ha grazing property was 18 km south-south-east of Mansfield, Victoria, Australia (37°09'43"S., 146°11'76"E., elevation 400 m). The native vegetation was almost completely cleared in the early twentieth century, with only a few mature *Eucalyptus* spp. remaining in the paddocks, while the roadsides contain good numbers of Peppermint Gums *E. dives*, with some Blackwood wattles *Acacia melanoxylon*, Tree Violets *Hymenanthera dentata* and tea-trees *Leptospermum* spp. Daily rainfall was recorded. When purchased in autumn 1979 the homestead was poorly maintained and the run-down garden contained a mature orchard, Radiata Pines *Pinus radiata* and six Chusan (Windmill) Palms *Trachycarpus fortunei*. The trunks of Chusan Palms were clothed in dense fibre and old leaf sheaths. Mature Chusan Palms produce large quantities of black berries. The nearest three neighbouring houses were approximately 200, 400 and 1000 m away. Since this time, two new houses have been constructed at approximately 600 and 800 m.

Methods of control included harbour removal and trapping. As sparrows were using the house for roosting, the following actions were taken to reduce harbours: roof ventilation eaves and entrances to the ceiling space were blocked with fly wire; entrances to wall cavities were timbered over; canvas verandah blinds were removed as birds were nesting in the ends of the rolls; as sparrows were breeding in the tops of the 6 m high Palms, the Palms were removed in winter; domestic chickens were not kept after 1989.

A Weekly Times Sparrow trap (Anon. 1978) was constructed (Fig. 1) and operated from early 1983. Across the framework at the bottom of the V is a strip of wire netting between 7 and 10 cm above the ground, 'the height must not exceed 10 cm', presumably to prevent birds turning over and escaping. At intervals along the middle of it are three holes 2.5 to 4 cm in diameter. The trap was operated by sprinkling wheat grain on the ground under the central V. Inquisitive birds jump down through one of the enlarged reinforced holes. The sides of the V are solid. Once inside, the birds are attracted to the light at either end of the trap in order to escape. Once in the enlarged 'box' ends the birds may flit from end to end without perceiving the entrance holes which are over-shadowed by the solid sides of the V. The openings on each end are to admit an arm to capture and remove sparrows. Captured House Sparrows were humanely killed.

The trap was placed within 10 m of the house where it was under easy surveillance. When close supervision was not possible the trap entrance was sealed off with a heavy board or the trap was overturned. Daily records of trapping operation

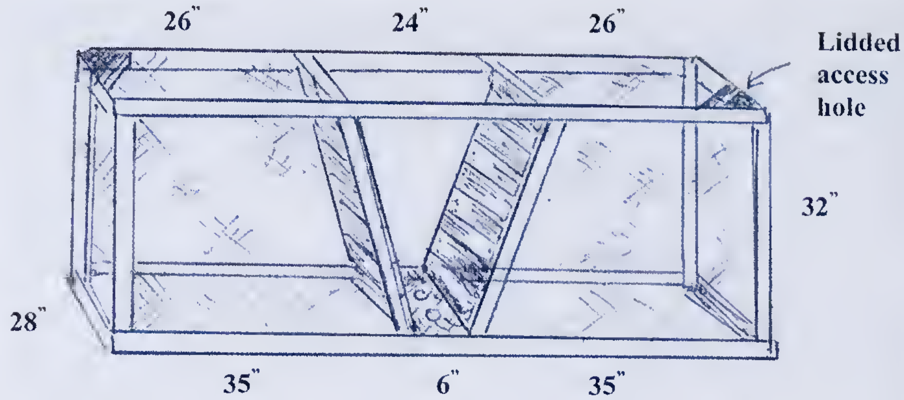


Fig. 1. The Weekly Times sparrow trap showing the central V with entrance holes. Dimensions shown in inches accord with those published by Anon (1978). One inch equals 2.5 cm.

and trapping success were kept. Observations of bird age and behaviour were kept.

Results

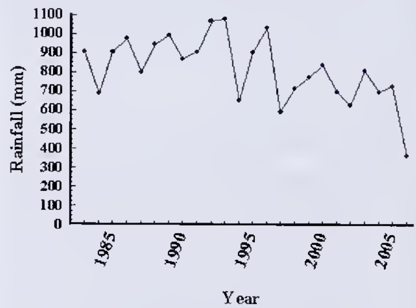
Rainfall is shown in Fig. 2. Mean ± s.d. annual rainfall during the period was 815 ± 170 mm.

Harbour removal was 100% effective in preventing roosting in the house ceiling space. The noise and constant chirruping of roosting sparrows was eliminated. The felling of the palms revealed masses of sparrow nesting material. As a result of these measures, few sparrows were seen sitting on the gutters used to collect domestic drinking water.

From its initial operation, the trap was effective in capturing House Sparrows. During the period of operation 643 sparrows were caught. The trapping results show a cyclical pattern (Fig. 3). From 1994 the numbers trapped declined to zero and it was not until 1999 that small numbers were again seen and captured.

The majority of sparrows were caught in summer (85%, Fig. 4). Since 1992, 90% of captured birds were immature individuals or juveniles with retained yellow fleshy gapes. Juvenile birds usually entered the trap promptly. Trappings during autumn and early winter amounted to 14%. Less than 1% of captures were during midwinter to late spring (July-November).

Once resident sparrow numbers were reduced to zero, birds arriving in summer



and autumn appeared nervous. Often the small numbers (often only one) would not stay and the sparrows dispersed before the trap could be set and supervised. There were long periods when no sparrows were observed and the trap was not set. Other small native birds such as Superb Blue Wrens, White-browed Scrub Wrens and Red-browed Firetails were rarely, but sometimes, captured in the trap, as these birds are also inquisitive explorers. Thus supervision during the day was required to release these 'by-catch' birds without delay. A few sparrows learnt to escape. These birds were captured by the operator working in the garden nearby and keeping the trap under very close observation.

When neighbours, who were unaware of the trapping program, were asked about numbers of sparrows at their homesteads, they replied that there were 'not many seen lately'.

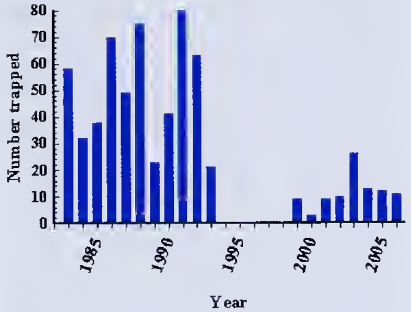


Fig. 3. The number of sparrows trapped each year from 1983 to 2006.

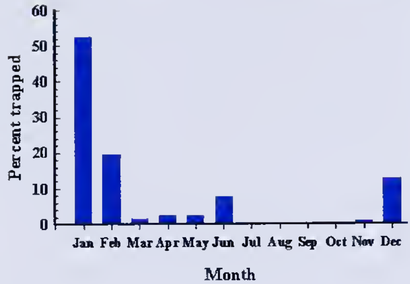


Fig. 4. The percentage of sparrows trapped by month of the year for the period 1992-2006 (n = 118).

Discussion

We have shown that is possible to operate a trap to depopulate a locality of House Sparrows associated with a rural dwelling. This property has had no resident House Sparrows since 1993 (over 13 years). This experience accords with the observations made in the Weekly Times Handbook that 'Experience has shown that the birds usually keep to one locality, and if measures are taken during winter and autumn, when food is scarce, their numbers can be greatly reduced' (Anon 1978, p 189).

From an ecological perspective, what was the effective locality in the present case? If the area depopulated by this single trap is assumed to include the neighbouring properties, then a total area of 600 ha may have been cleared or substantially cleared. Further work is required to substantiate this observation.

The continuing construction of buildings and homes in rural Australia is providing more habitats for House Sparrows. The increasing number of residences also provides the opportunity for the strategic location of traps to allow depopulation of wider areas. An opposite trend in House Sparrow populations may be evident in rural areas where farm amalgamation is leading to the abandonment of homesteads with a reduction of suitable habitat. Evidence for this is provided by analysis of data from *The New Atlas of Australian Birds* (C Tzaros 2005 pers. comm.).

The ability to depopulate a rural area with a single trap has implications for ecological restoration. This experience contrasts sharply with the conclusions of previous reports (Anon 1995; Harrison and Congdon 2002) and challenges the notion of Harrison and Congdon (2002) that poisoning is the only method of removal of House Sparrows. It is possible to change the pest status of House Sparrows on a local scale from residents to uncommon seasonal visitors. This is not an unreasonable strategy as House Sparrows are closely associated with humans (Long 1981; Blakers *et al.* 1984). We therefore propose the hypothesis that, in rural areas, control at the homestead level is the most appropriate scale for effective elimination of House Sparrows.

It took some years to depopulate the home area. House Sparrows can live for at least six years (Jensen *et al.* 2004). It is suspected that the sudden collapse of sparrow numbers in 1994 was because of the death of mature breeding birds due to old age, as a large proportion of trapped sparrows in the years just prior to 1994 had been yellow-gaped juveniles dispersing to new areas. Using the methods described to depopulate the home areas therefore involves the removal of all adult sparrows, their offspring, any dispersing sparrows from neighbouring areas, and harbour removal. The complete depopulation of sparrows lasted for five years (1994-1998), before further trapping was required.

A number of issues have not been controlled in this study. For example, the food supply from domestic chickens, dogs and cats would have varied according to the number of houses in the neighbouring area or the preferences of occupants in those houses. Thus the increased number of House Sparrows trapped from 1999 may

be related to the establishment of populations at the new houses. A wider survey would be of interest.

Clearly an area that has been depopulated of House Sparrows can be re-infested by dispersing juvenile birds. Re-infestation in this locality occurred only in midsummer. It is unclear if further trapping was actually required to capture the dispersing House Sparrows that arrived from 1999 but the risk of not trapping could undermine work to eliminate the original population. The fate of dispersing House Sparrows seen at the homestead but not trapped is unknown.

How far House Sparrows can disperse in one season is not clear. Blakers *et al.* (1984) provide observations that imply dispersal rates of 6.7 km/year in arid areas of South Australia to 85 to 103 km/year in settled farmland in Queensland. In Boorolite, dispersal was not always successful as five years passed between elimination and re-colonisation as suggested by trapping. During this five-year period, House Sparrows passed through this farm but did not stay. The failure of these dispersing House Sparrows to adopt a potential new home suggests factors other than the presence of humans affects the attractiveness of a potential new habitat.

It is relevant when promoting the trapping of House Sparrows to other rural landholders that the benefits arising to them from the removal of House Sparrows should be carefully explained. The removal of sparrows in this work was associated with an improved amenity in four areas.

1. Noise. The incessant chirruping of the sparrows was eliminated. This was particularly noticed at dawn but also during flocking and breeding times.
2. Health and water quality. There was complete removal of sparrow faeces, nesting material and feathers from the verandahs, ceiling, roof, spouting and tanks. Sparrows commonly rest on guttering and roost in roof spaces. This is associated with defecation into the water supply of the household. While no records were kept of *Escherichia coli* levels in the water supply, there was no risk of infection from House Sparrows as they were no longer present. A detailed study of this aspect of risks to human health would be of interest. There are more than 60 transmittable diseases that are associated with pigeons, starlings and sparrows. In New Zealand, House Sparrows have been implicated in maintaining and spreading *Giardia* and *Cryptosporidium* infections on farms (Chilvers *et al.* 1998). Alley *et al.* (2002) reported an outbreak of salmonellosis due to *Salmonella typhimurium* DT160 which caused extensive mortality in wild birds and enteric disease in humans in New Zealand. Isolates from birds, livestock and humans were indistinguishable from one another. Because of the close association between House Sparrows and humans, Alley *et al.* (2002) concluded that the organism poses a serious zoonotic risk. Bird droppings can contain pathogenic fungi and bacteria that cause histoplasmosis, chlamydiosis, cryptococcosis and other lung diseases in humans (Anon 2005). Commercial pest control companies in Australia advise that bird droppings in areas such as external air-conditioning units, window ledges, pathways, water treatment or supply systems, and pedestrian entrances should be removed as soon as possible, to eliminate possible health and safety risks to the public.
3. Improved growth in the vegetable garden. Sparrows eat emerging seedlings of lettuce, beetroot etc. Replanting these seedlings loses three weeks in an already short season between the chill of winter and the heat of summer.
4. A return of native birds, particularly finches. Long (1981) reported that House Sparrow distribution is aided by human activity and that throughout this range they are not known to have competitively replaced native species in undisturbed habitat, although some species displacement must have occurred. However Blakers *et al.* (1984) state that House Sparrows 'often drive native birds from nest sites'. In the present study, the removal of the House Sparrows was associated with the return of native finches. Sparrows are territorial in the sense that they closely follow human settlement (Blakers *et al.* 1984). The return of finches may have been circumstantial or associated with the provision of plan-

tations, and fenced-off areas with long ungrazed grass etc. However in the 14 years prior to the removal of House Sparrows, no native finches had been seen on the farm.

The trap was easily made and worked effectively. All that was required was to keep up the supply of bait and to effectively supervise the trap. Traps work because of the behaviour of sparrows that chirrup to bring in other individuals when they find a new food resource that is divisible (Elgar 1986). Sparrows prefer to be in flocks. Individual sparrows appear nervous and are clearly more vulnerable to predators (Harkin *et al.* 2000). Sparrows nest in spring and early summer. Juvenile sparrows were captured when they moved beyond adult care. The juveniles formed flocks and migrated from midsummer. This flock-forming and migration to new feed sources by juveniles accords with previous observations about feeding efficiency of House Sparrows (Elgar and Catterall 1982). In winter, very few birds arrived, as presumably birds kept to known sheltered areas. These observations demonstrate that the best time to trap House Sparrows is between late January and June. Once House Sparrow numbers are low then the trap needs to be used on only the rare occasions when they arrive.

The best location of the trap is where it can be kept under observation. In other words, let the sparrows come to it rather than taking the trap to where the sparrows might be. Clearly House Sparrows are able to rapidly find a food source as was seen when newly arrived juvenile birds entered the trap within hours of arrival. Uneaten bait may attract vermin, so it is suggested that the trap should be on a hard surface to prevent them from burrowing under the edges to reach the grain. As finches need water, having a source of water close by, such as in a bird bath, may help in monitoring the presence of House Sparrows.

An important detail in the construction of the Weekly Times Sparrow Trap is the central V where a strip of netting is stretched across the framework. The instruction given must be followed carefully. It would assist the operation of the trap if the sides of the V are dark in color and the top of the central section above the V could be covered to exclude the overhead view of the sky. The Weekly Times Sparrow Trap is large and cumbersome to move. We constructed a smaller trap to enable easier operation, and other designs are also available.

These findings should encourage others to view House Sparrows as pests that can be eliminated with judicious trapping (care, skill and observation) and the removal of harbours. The present study demonstrates that House Sparrows are a problem that does not have to be tolerated.

Conclusion

The use of a trap, from late summer to midwinter, along with harbour removal, enabled the elimination of a population of House Sparrows. Sparrow traps were easily made, and worked effectively when supervised. We propose that in rural areas control at the homestead level is the most appropriate scale for effective elimination of House Sparrows. Use of this approach over a catchment scale should be able to eliminate or reduce House Sparrow populations. A larger scale trial would be a worthwhile exercise particularly in areas where native bird biodiversity is under threat.

Note

The removal of House Sparrows (considered vermin and with no statutory protection within the State of Victoria), was undertaken by private individuals. Although the authors have carefully documented the process and outcomes, first and foremost these were management actions and never undertaken as research actions. While ethics approval for these activities was not necessary, every effort was made to treat all trapped individuals ethically. As such the trap was only set when close supervision was possible, any trapped House Sparrows were removed and humanely killed soon after capture and the small number of non-target species that were captured were immediately released.

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One Hundred Years Ago

EXCURSION TO THE YOU YANGS

In the surface of the granite several rock pools exist, which at the time of our visit were full of water, so that the tourist, except in the height of summer, should generally be able to secure water here, for as a rule the ranges are rather short of that commodity. A good spring also exists directly under the southern face of Station Peak.

From the largest of the pools I skimmed what I took to be a floating scum of fresh water algae, and, the situation being rather remarkable, I submitted it to Mr. A.D. Hardy, F.R.M.S., who has given me the following note:– "The material had unavoidably been much shaken up in transit, and appeared when received as a soapy green fluid with darker clots. Microscopically examined, it proved to be a mass of desmids of a single species only, *Closterium lanceolatum*, Kutzing, and, excepting numerous protozoa, no other organisms were present. This species occurs in various parts of Victoria, and was recorded from the weedy margins of Lake Colac a few years ago (*Vict. Nat.*, xxii, p. 66)."

The occurrence of an alga in such a remarkable position is most interesting, and shows that the most unlikely localities are often productive of unlooked-for results in both zoology and botany.

From *The Victorian Naturalist* **XXV** p. 126, December 10, 1908

Distribution of clonal and non-clonal wetland plants at Clydebank Morass, Gippsland Lakes, in relation to elevation and salinity gradients

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Abstract

A review of the published literature suggested that plants with a clonal growth habit dominated the vegetation of wetlands in many parts of the world. To test whether this pattern held in Australia, the distribution of plants with clonal and non-clonal growth habits was examined in Clydebank Morass, a brackish-water wetland of the Gippsland Lakes in south-eastern Victoria. Nineteen of the twenty species of aquatic or semi-aquatic plants present in the wetland were clonal. In terms of both species number and percentage cover, clonal plants dominated the vegetation in wet and intermittently damp parts of the Morass whereas non-clonal plants were progressively more common as elevations increased. This elevational effect was due more to changes in soil moisture content than in soil salinity. These results not only confirmed the prediction that clonal plants were the dominant growth habit in the wetland but were consistent with predictions made in the 1960s as to likely vegetation changes as the Gippsland Lakes became progressively salinised. Understanding the dominance of wetlands by clonal plants has implications for assessments of plant fitness and the maintenance of plant biodiversity and habitat heterogeneity; it is central also to improving the success with which degraded wetlands are rehabilitated. (*The Victorian Naturalist* **125** (1), 2008, 11-18)

Introduction

Clonal plants are those that can reproduce asexually and spread as a population of semi-independent parts of what was originally a single seedling (Harper 1977). Clonal growth and vegetative reproduction may occur in many ways, including the production of rhizomes, stolons, tubers, turions and plantlets, fragmentation of the plant body, and node rooting. Many of these features are evident in well-known and widely distributed wetland and aquatic plants – for example willows *Salix* spp., Eel Grass *Vallisneria* spp., Common Reed *Phragmites australis* and Cumbungi *Typha* spp. Indeed, a number of international studies have indicated that wetlands are often dominated by clonal plants, which can reproduce vegetatively as well as sexually by seed when environmental conditions permit (Mühlberg 1982; Cook 1990; Grace 1993; Oborny and Bartha 1995; van Groenendael *et al.* 1997; Crow and Barre Hellquist 2000). For example, 61% and 68% of the aquatic or wetland plant species in North Carolina and Florida, respectively, are clonal (Beal 1977; Tarver *et al.* 1978). Spencer Jones and Wade (1986) reported that 88% of vascular aquatic plant species in the British Isles are clonal. Clonal plants also have been shown to dominate the floristics of wetlands in Central Europe (Klimeš *et al.* 1997; L. Klimeš, pers. comm. 2005) and China (Song and Dong 2002).

There have been no comparable studies undertaken to examine the importance of clonality in the vegetation of wetlands of temperate south-eastern Australia, but a review of plant descriptions in the three most important monographs on Australian aquatic and wetlands plants in this region – Aston (1977), Romanowski (1998) and Sainty and Jacobs (2003) – indicated that 288 of the 450 described taxa (64%) were clonal and capable of vegetative reproduction. The ratio of approximately 2:1 for clonal to non-clonal aquatic plants was consistent across all three references: 65% in Aston (1977), 61% in Romanowski (1998) and 71% in Sainty and Jacobs (2003). This result would suggest that Australian wetlands, like wetlands in the Northern Hemisphere, are likely to be dominated by clonal plants. Nevertheless, to our knowledge there have been no studies that have attempted empirically to quantify the incidence of clonality – either floristically or in terms of cover or abun-

dance – in an Australian wetland. Moreover, it is unclear even from overseas studies as to what environmental factors are most important in controlling the relative distributions of clonal and non-clonal plants in wetlands.

The research reported in this paper had three aims. The first was to test the hypothesis that clonal plants dominated the aquatic and semi-aquatic vegetation in Clydebank Morass, a brackish-water wetland of the Gippsland Lakes in eastern Victoria. This question was addressed by undertaking vegetation surveys at two contrasting times of year to quantify the relative incidence of clonality in the wetland's aquatic and semi-aquatic vegetation. The second aim was to determine whether the distributions of clonal and non-clonal plant species varied with environmental conditions, especially elevation and soil water content and salinity. The third aim was to use these data on floristics, vegetation cover and environmental conditions to address a number of predictions made in the 1960s as to the likely historical trajectory of plant communities in wetlands that fringe the Gippsland Lakes, with particular reference to increasing salinity. In a series of pioneering papers by ECF Bird in the 1960s (Bird 1961, 1962, 1966), it was predicted that wetlands and fringing vegetation along the Gippsland Lakes would be affected by increasing salinity arising from the artificial opening at Lakes Entrance. Bird (1966) specifically raised the possibility that inexorably increasing salinity would cause the replacement of reed swamp (Common Reed *Phragmites australis*, then known as *P. communis*) by swamp scrub (Swamp Paperbark *Melaleuca ericifolia*) and eventually swamp scrub by even more salt-tolerant salt marsh communities.

Methods

Field site

Clydebank Morass (38°02'50"S, 147°14'00"E) is a shallow (z_{max} = 1-2 m), brackish-water wetland of about 1420 hectares in Gippsland, Victoria. It is one of a chain of Ramsar-listed, brackish-water wetlands along the perimeter of Lake Wellington, the westernmost waterbody of the Gippsland Lakes. Clydebank Morass is a State Game Reserve, managed primarily for waterbird breeding and hunting and habitat values. The wetland has been connected permanently to Lake Wellington since about 1990, when high water levels in the lake breached the low-lying boundary between the Morass and Lake Wellington.

Vegetation surveys

Floristic surveys were undertaken in late summer (March 2004) and winter (June 2004) to quantify the relative proportions of clonal and non-clonal species. These two survey periods were chosen to maximise the number of plant species identified in the wetland, within the constraints of the time available for field-based assessments. To determine whether the ratio of clonal to non-clonal taxa varied with elevation, 20 belt transects (50 cm wide) were run in July 2004 from the water-line to the most elevated level where terrestrial vegetation bordered the Morass. Transects varied in length from 50 to 100 m and were divided into contiguous 1 m long quadrats. Transects were positioned systematically rather than randomly because systematic samples are particularly well-suited to detecting vegetation changes along environmental gradients and, in such cases, random sampling would generate an arbitrary set of values for species abundance (Kershaw 1973).

Plant cover for vascular plant species in each quadrat was estimated using the Braun-Blanquet scale (0 = 1-5% cover; 1 = 5-10%; 2 = 10-25%; 3 = 25-50%; 4 = 50-75%; and 5 = 75-100%). An inclinometer was used to estimate transect elevations: elevations are given in terms of vertical height above the water level and not with reference to the Australian Height Datum. This decision was necessitated by the lack of survey data or a digital elevation model for the site. Using known measurements of transect lengths and differences in elevation (calculated from inclinometer readings), each of the 20 transect gradients was broken into 0.25 m elevations to allow the zonation width of different taxa to be mapped in terms of elevation above the shoreline. Plant nomenclature follows that of Ross and Walsh (2003).

Soil characteristics

Soil cores were taken in September 2004 to determine whether there were consistent variations in soil water or salt contents

along the elevational gradients or from zones with contrasting vegetation along a single transect. Three replicate soil cores (5 cm diameter x 10 cm deep) were taken at each quadrat; in total 228 cores from 76 different quadrats were analysed. Soils were sampled to only 10 cm because the species present, even Swamp Paperbark, are quite shallow rooted. Soil cores were oven dried at 105° C to determine moisture contents (MC%, expressed as a percentage of dry-soil weight). To determine salt contents, subsamples were ground with a mortar and pestle, made into slurries (1:5 soil:water), then shaken by inversion for one hour at 25° C (Rayment and Higginson 1992). The temperature-adjusted electrical conductivity of the slurries was converted to salt concentrations (mg L^{-1}) using a conversion factor of 0.6 then tabulated in units of g L^{-1} of soil pore water.

Results

Relative proportions of clonal and non-clonal species

Ninety plant species from 31 plant families were identified during the two floristic surveys. Exactly one half of the species present were clonal, though this figure increased to 59% when only native taxa were considered (Table 1). Native species accounted for 64% of the species and non-natives 36%; the non-natives were mostly introduced annuals. Guerilla and phalanx clonal growth habits (*sensu* Lovett-Doust 1981) were both well represented at 53 and 47%, respectively. Clonal plants with a guerilla growth habit tend to have long stolons or rhizomes, which allow them to penetrate deeply into new habitats. In contrast, plants with the phalanx growth form tend to have short stolons or rhizomes and colonise new habitats on a broad front, the metaphor reflecting a massed body of infantry drawn up in close order and advancing slowly into new areas. Of the 90 species present in the morass, only 20 were classified as aquatic or wetland plants (Table 2). The definition of aquatic plants was fairly broad and followed the descriptions given by Best (1988) and Sainty and Jacobs (2003). This definition allows for the accommodation of woody tree species, such as Swamp Paperbark and willows, as well as herbaceous taxa.

Table 1. Incidence of clonality in plants at Clydebank Morass, Gippsland Lakes, south-eastern Victoria.

Characteristic	No of species	%
Total number of plant species	90	100
Native species	58/90	64
Exotic species	32/90	36
Clonal species	45/90	50
Native clonal species	34/58	59
Putative guerilla growth habit	24/45	53
Putative phalanx growth habit	21/45	47
Aquatic species	20/90	22
Clonal aquatic species	19/20	95

Of the 20 species found in aquatic or semi-aquatic environments in Clydebank Morass, 19 were easily classified as clonal. The one remaining species, Greater Sea-spurrey *Spergularia media* was an exotic native to Europe and North America, where it typically grows as a perennial above the water-line. At this study site, however, Greater Sea-spurrey was found at the water-line and displayed a growth and senescence cycle typical of an annual species. As there was no evidence of node rooting or other asexual growth, Greater Sea-spurrey was classified as non-clonal. Accordingly, 95% of the wetland plants present in Clydebank Morass were unambiguously clonal.

Variations with elevation and soil salinity

Clonal species completely dominated the vegetation of Clydebank Morass at lower elevations, and the proportion of clonal species declined consistently with increasing elevation (Fig. 1). Clonal species accounted for more than 70% of the total number of species in the first metre of vertical elevation and approximately 50% of species up to an elevation of 2.5 m. At elevations greater than 3 m from the water-line, the number of clonal taxa declined to around 20% and remained at this value until the highest elevation (6 m) examined in this study. The dominance of clonal taxa was evident not only in terms of floristic criteria (Fig. 1) but also in terms of percentage cover: up to an elevation of about 2 m, clonal plants provided a cover of >75% (Fig. 2).

The distribution of individual plant taxa also varied with elevation. Common Reed

Table 2. Range of clonal attributes possessed by wetland plants at Clydebank Morass, Gippsland Lakes, south-eastern Victoria. * indicates an exotic species. SM indicates a species identified as a salt-marsh plant by Bridgewater *et al* (1981).

Family	Species name	Common name	Clonal attribute
Aizoaceae	*Disphyma crassifolium*SM	Purple Noon-flower	Node roots
Asteraceae	*Cotula coronopifolia*SM	Water-buttons	Node roots
	Leptinella longipes	Coast Cotula	Stolons
Caryophyllaceae	*Spergularia media**	Greater Sea-spurrey	Non-clonal
Chenopodiaceae	*Sarcocornia quinqueflora*SM	Beaded Glasswort	Stolons
Cyperaceae	*Baumea arthrophylla*	Soft Twigrush	Rhizomes
	Bolboschoenus caldwellii	Sea Club-rush	Rhizomes
	*Eleocharis minuta**	Variable Spike-rush	Stolon or rhizomes
	Eleocharis pusilla	Small Spike-rush	Rhizomes
	*Isolepis nodosa*SM	Knobby Club-rush	Rhizomes
Goodeniaceae	*Selliera radicans*SM	Shiny Swamp-mat	Node roots
Juncaceae	*Juncus pallidus*	Pale Rush	Rhizomes
	Juncus kraussii subsp. *australiensis*SM	Sea Rush	Rhizomes
Juncaginaceae	*Triglochin striatum*SM	Streaked Arrow-grass	Rhizomes
	Triglochin procerum	Water-ribbons	Tubers and rhizomes
Myrtaceae	*Melaleuca ericifolia*	Swamp Paperbark	Suckers and rhizomes
Poaceae	*Phalaris aquatica**	Toowoomba Canary-grass	Rhizomes
	Phragmites australis	Common Reed (Djarg)	Rhizomes
Scrophulariaceae	*Mimulus repens*	Creeping Monkey-flower	Node roots
Typhaceae	*Typha domingensis*	Cumbungi, Bulrush	Rhizomes

Phragmites australis, for example, was present only at the wettest end of elevational gradients, up to about 0.5 m elevation (data not shown). In contrast, a second set of plant taxa, consisting of Sea Rush *Juncus kraussii*, Purple Noon-flower *Disphyma crassifolium*, Swamp Paperbark and Blue Tussock-grass *Poa poiformis*, was present in the ephemeral ecotonal zone with mean elevations extending to approximately 1.25 m above the water level. Vegetation in the highest, and driest, zone consisted of Australian Salt-grass *Distichlis distichophylla* and exotic annual species, mostly pasture escapes.

This pattern of plant distributions was related more to variations in soil moisture content than the salinity of the soil pore water. There was a gradual decrease in the mean soil moisture content from the wettest zone colonised by Common Reed (93% w/w soil-moisture content) and Sea Rush (85%) to values of 61% in soils beneath Blue Tussock-grass stands and 50% under Purple Noon-flower. A one-way analysis of variance (ANOVA) showed a significant difference ($F_{5,74} = 9.138$, $P < 0.0001$) in mean soil-moisture content across this gradient. In contrast to the results obtained with soil-moisture contents, average soil salinities were not significantly different (one-way ANOVA: $F_{5,74} = 1.474$, $P > 0.05$) with elevation across the transects. The highest average soil salinity was recorded beneath Swamp Paperbark (21 g L^{-1}) in the peaty ephemeral ecotone, whereas the lowest average soil salinity (17 g L^{-1}) was recorded beneath Common Reed, at the wettest end of the gradient. Because of the nature of the conversion from electrical conductivity to salinity, these salt concentrations should be regarded as only approximate.

Discussion

Our surveys at Clydebank Morass indicated that 19 of the 20 aquatic or semi-aquatic species present were clonal, and the single remaining species that was not clonal, Greater Sea-spurrey, was an exotic native to Europe and North America, where it typically grows as a perennial above the water-line. This empirical analysis confirms the pattern presented in the main taxonomic monographs covering wetland and aquatic plants in southern Australia (Aston 1977; Romanowski 1998; Sainty and Jacobs 2003), as well as a large number of comparable studies undertaken on the incidence of clonality in wetlands in Europe, the Americas and Asia (see Introduction).

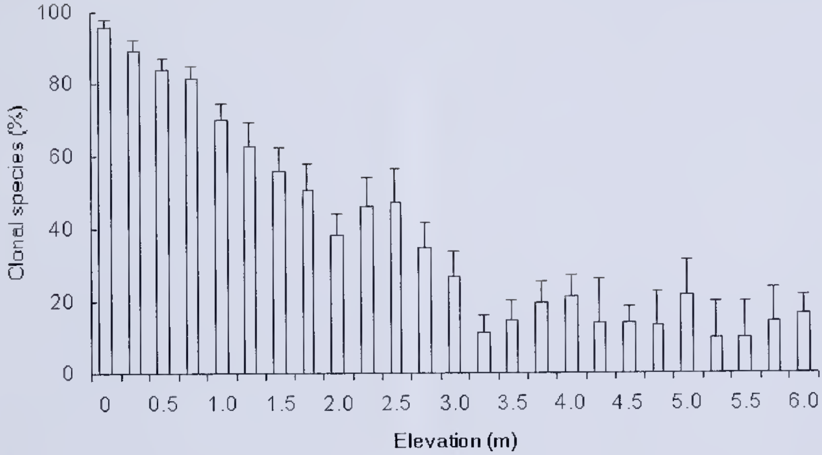

Fig. 1. Percentage of clonal plants, as a proportion of total species, in relation to elevation at Clydebank Morass, Gippsland Lakes, south-eastern Victoria. Means and standard errors are shown, n = 20.

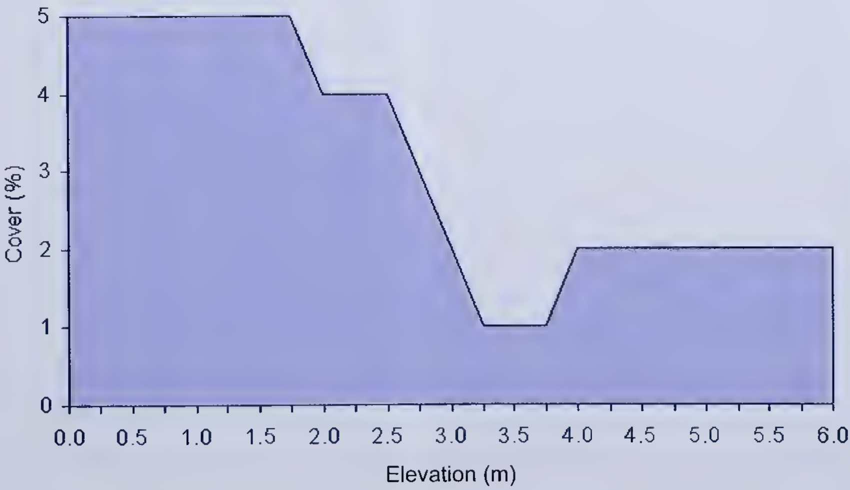

Fig. 2. Percentage cover of clonal plant species along 10 elevational gradients at Clydebank Morass, Gippsland Lakes, south-eastern Victoria. The Braun-Blanquet scale is used as the index of cover on the y-axis (0 = 1-5 % cover; 1 = 5-10 %; 2 = 10-25 %; 3 = 25-50 %; 4 = 50-75 %; and 5 = 75-100 %).

It seems that Clydebank Morass is similar to wetlands in other parts of the world in that its aquatic and semi-aquatic vegetation is overwhelmingly clonal. The dominance of clonal plants has a number of important implications for the understanding and rehabilitation of wetland vegetation. First, it has implications for assessing plant fitness. The occurrence of seeds is commonly used as a measure of fitness for plants, as seed production through outcrossing ensures genetic recombination and creates a diverse and resilient gene pool (Eriksson 1997). Although fitness is traditionally calculated by forecasting the expected seed output of a plant over its lifetime, estimating the lifetime seed production for clonal plants can be very difficult as these plants are potentially immortal and may produce innumerable offspring in the form of clonal propagules and ramets, as well as seeds (Wikberg 1995; Santamaría 2002). Indeed, Pan and Price (2002) argued that an emphasis on seed production has meant that clonal growth has been ignored as a critical component of plant fitness.

Botanists have traditionally seen clonal growth ability as an adaptation to complement the dispersal of seeds (Grace 1993). There are a number of reasons indicating that this view should be reversed when wetland plants are considered, and that the obverse view – that sexual reproduction plays the complementary role to vegetative reproduction – should be erected in its place. In wetlands, recruitment events from seed are irregular and highly unpredictable and seed germination is often dictated by subtle changes in hydrological conditions (Brock and Britton 1995; Rea and Ganf 1994; George *et al.* 2005; Capone and Brock 2006). This means that conditions suitable for sexual recruitment may occur at relatively few times of the year or, in the case of wetlands with variable hydrological regimes, only in a few years every couple of decades. Moreover, the seeds of even dominant wetland plants may be short-lived and this can prevent the formation of a soil seed bank; such a pattern has been demonstrated recently for Lignum *Muehlenbeckia florulenta* by Chong and Walker (2005). In contrast to sexual reproduction, the period suitable for vegetative growth and propagation by wetland plants is not restricted to a single season or rare time of year having the requisite water regime. Furthermore, as seed or diaspore production is often a function of biomass, long-term persistence through clonal offspring offers a greater probability of continual seed output, so that viable seed will be present within the wetland system if suitable conditions for germination do occur.

Second, the ubiquity of the clonal growth habit has implications for the production and maintenance of habitat diversity in brackish-water wetlands. Large clonal plants, such as Swamp Paperbark, that grow mostly at the lower elevations of the Morass provide more structural and topographical complexity in the landscape than do non-clonal species. At high elevations, structural complexity may be driven largely by season, as temporary gaps are created in the vegetation with the rapid germination, maturation and death of annual species. In contrast, at lower elevations tall phalanx species such as Common Reed, Sea Rush and Swamp Paperbark border one another and are often carpeted beneath by low-growing guerilla species, such as Streaked Arrow-grass *Triglochin striatum,* Shiny Swamp-mat *Selliera radicans,* Creeping Monkey-flower *Mimulus repens* and Purple Noon-flower. The combination of tall phalanx and short guerilla clonal architecture creates a rich mosaic of structure and microtopographical relief.

Finally, the prevalence of clonality has implications for wetland rehabilitation. Seed banks feature prominently in the scientific literature on wetland revegetation and rehabilitation (e.g. Brock and Casanova 2000). If, however, many wetland plants recruit, disperse and colonise new areas primarily by vegetative means, wetland managers will have to reconsider the strategies for rehabilitating degraded wetland sites. Three issues seem most important and their resolution may help redress the general failure of wetland rehabilitation in southern Australia reported by de Jong (1997). First, seed may not be the most appropriate mechanism for re-introducing plants into degraded sites: Chambers *et al.* (1995) noted that vegetative recolonisation (e.g. with rhizomes) was the best form of propagation for a wide range of important wetland plants in

south-western Australia, including Jointed Twig-rush *Baumea articulata*, Bare Twig-rush *Baumea juncea*, Pithy Sword-sedge *Lepidosperma longitudinale* and River Club-sedge *Schoenoplectus validus*. Second, the spatial heterogeneity created by large clonal plants may provide opportunities for improving the success of revegetation trials. In earlier field trials the survival of Swamp Paperbark tubestock was improved markedly by planting seedlings into raised hummocks of Water Couch *Paspalum distichum* (Raulings *et al.* 2007). This experimental finding is consistent with field observations that Swamp Paperbark seedlings and juveniles occur mostly on hummocks that offer respite against the stressful combination of waterlogging, salinity and soil acidity occurring in surrounding sediments. Third, the incidence of clonality may force a re-assessment of the number of plants that need to be introduced per unit area of wetland during revegetation trials. Taking a lead from terrestrial precedents, revegetation trials in wetlands commonly involve planting on close (e.g. 1 m) centres. Since many wetland plants are not only clonal but have short-lived seed (e.g. willows: Sainty and Jacobs 2003; Lignum: Chong and Walker 2005), most of the plants of a given species in a wetland were probably derived from one or few individuals. It may be more appropriate to plant large, long-lived clonal species at far lower densities than is the current common practice and let them develop into discrete but extensive stands over the subsequent decades. This recommendation is, however, not to underestimate the importance of the prodigious amounts of seed that can be produced by some wetland taxa, e.g. *Typha* spp., and the problems this causes for the spread of unwanted species into newly constructed or rehabilitated wetlands.

As well as these implications that are probably widely applicable across south-eastern Australian wetlands, the research findings throw light also on the predictions made over 40 years ago by ECF Bird (1961, 1962, 1966) for fringing and wetland vegetation of the Gippsland Lakes. When the Gippsland region was first settled by Europeans in the 1840s, the Gippsland Lakes were linked with the Southern Ocean by a shifting and intermittent outlet through the sand barriers between Cunninghame and Red Bluff at the easterly part of Lake King. Although they would open to the sea during large floods, to improve navigability an artificial entrance was cut to the ocean in 1889 at Lakes Entrance, about 5 km from the natural entrance. It is believed that a major consequence of opening the artificial entrance has been to increase the salinity of the Gippsland Lakes, which previously were relatively fresh, being fed by the rivers flowing into Lakes Wellington and King and having only an intermittent linkage with the ocean. Bird (1966) predicted that, because of this progressive and inexorable increase in salinity, the fringing vegetation of the Gippsland Lakes would change as salt-intolerant taxa, such as Common Reed, were replaced by taxa tolerant of the higher salinities, such as Swamp Paperbark and, ultimately, salt marsh species. The findings of our study indicate not only that soils in Clydebank Morass were highly saline (17-21 g L^{-1} at the times of sampling in 2004) but that taxa typical of salt marsh communities were abundant in the wetland. Table 2 identifies those species present in the Morass that were listed in the monograph on salt marshes of southern Australia by Bridgewater *et al.* (1981): it is obvious that a large number of the taxa present in 2004 were, indeed, salt-tolerant salt marsh representatives. Thus the data presented here are consistent with the historical trajectory predicted for fringing and wetland vegetation along the shores of the Gippsland Lakes by Bird (1966). Further historical analysis is required to determine whether these taxa were present before salinities in the Gippsland Lakes apparently commenced their recent increase.

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Leaf litter invertebrate assemblages in box-ironbark forest: composition, size and seasonal variation in biomass

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Abstract
Ground-dwelling invertebrates are an important component of the box-ironbark forest ecosystem, but have been relatively little studied. This study quantified the composition, size and seasonal variation in biomass of leaf litter invertebrates in a box-ironbark forest in Victoria over a period of two years. Invertebrates were extracted using Tullgren funnels in one year and by hand-sorting in a subsequent year. Seven classes of arthropod were identified. Hymenoptera was the most numerous taxon comprising 22% and 29% of the invertebrates extracted in each year. Most invertebrates were small: 81% extracted using Tullgren funnels (minimum length 0.1 mm) and 77% extracted by hand-sorting had a body length of less than 5.0 mm. There was significant seasonal variation in the biomass of the leaf litter invertebrates, with a short peak of one to two months' duration from the end of winter, that is, at the end of the coldest and wettest period of weather. The time of lowest biomass was during the summer months (December, January and February), the hottest and driest period of the year. The biomass of leaf litter invertebrates was significantly correlated with the moisture content of the leaf litter. (*The Victorian Naturalist* **125** (1), 2008, 19-27)

Introduction

At the beginning of the 19th century, box-ironbark forest was the dominant vegetation type along the inner slopes of the Great Dividing Range from Victoria to central New South Wales and covered approximately 1 million hectares. Between 75% and 85% of the original cover has been cleared (Calder *et al.* 1994; Victorian National Parks Association VNPA 1999). Surviving remnants are highly fragmented and severely altered in structure through a combination of firewood and timber collection, mining, inappropriate burning and livestock grazing (Bennett 1993; Calder 1993; Robinson 1993; Sivertsen 1993; Traill 1993; Bromham *et al.* 1999). Few large old trees remain and the understorey and ground layers have been degraded with little decomposing timber on the ground.

Box-ironbark forests typically have a diverse flora and fauna, including many rare and threatened species. Ground-dwelling invertebrates play essential roles in the decomposition of organic material and the cycling of nutrients, and are the base of the food chain for many vertebrates (Yen *et al.* 1999). At least 15 species of box-ironbark forest birds, including the White-winged Chough *Corcorax melanorhamphos*, White-browed Babbler *Pomatostomus superciliosus* and robins *Petroica* spp. and *Eopsaltria australis*, are ground-foragers, depending mainly on leaf litter invertebrates (Laven and Mac Nally 1998). White-browed Babblers spent 95% of their foraging time on the ground searching amongst leaf litter for invertebrate prey (Taylor 2003).

Because of their importance for insectivorous, ground-foraging vertebrates and their broad influence within the box-ironbark ecosystem, information on leaf litter invertebrates is essential for an ecological understanding of box-ironbark forests and their management. Despite this there are relatively few published studies. An initial investigation of the diversity of ground-dwelling invertebrates across the box-ironbark region in Victoria yielded 35 orders and quantified their relative abundance (Yen *et al.* 1999). However, there have been no detailed studies of the size distribution of ground-living invertebrates or of their seasonal variation in abundance, although leaf litter invertebrate abundance and diversity have been examined in relation to human interference in Grey Box *Eucalyptus microcarpa* woodland in Victoria (Bromham *et al.* 1999). The identification of seasonal changes in abundance of invertebrates in eucalypt forests and woodlands in general has proved difficult

because of the diversity of organisms, the variety of short-term and long-term environmental influences on abundance and year to year variation (Ford 1985).

This study examined the composition, size and seasonal variation in the biomass of leaf litter invertebrates in a box-ironbark forest. Temperature and rainfall were recorded to allow comparison with seasonal changes in the biomass of the invertebrates.

Methods

Study area

The study took place within the box-ironbark forest of Chiltern-Mount Pilot National Park in north-eastern Victoria (36°10′S, 146°37′E). This forest type occurred in a 4320 ha northern section of the park and is the most north-easterly representation of box-ironbark forest in Victoria. The vegetation is dry sclerophyll, open forest mostly comprising two Ecological Vegetation Classes: 'Box-Ironbark Forest' and 'Heathy Dry Forest' (Muir *et al.* 1995). The eucalypt species are Red Ironbark *Eucalyptus sideroxylon*, Red Stringybark *E. macrorhyncha*, Blakely's Red Gum *E. blakelyi* and boxes: Red Box *E. polyanthemos*, Grey Box *E. microcarpa*, White Box *E. albens*, Long-leaved Box *E. goniocalyx* and Apple Box *E. bridgesiana*. These form an open canopy about 20-30 m high. The nature and extent of the understorey vegetation is variable but is generally sparse (less than 6% cover by area) (Taylor 2003) and mostly comprises Cherry Ballart *Exocarpus cupressiformis* and wattles *Acacia* spp., particularly Golden Wattle *A. pycnantha*. In some areas there are smaller shrubs, low herbaceous plants and/or grasses. The leaf litter is generally sparse and shallow (less than 2 cm deep).

The area was subjected to extensive and intensive alluvial and quartz reef gold mining in the mid to late 1800s when the forest was mostly clear-felled, with many of the remaining mature trees removed in the 1950s and 1960s (Meredith 1984). Thus the present forest is re-growth and relatively immature. The topography is undulating with broad gullies, rises and several prominent ridges. The altitude ranges from 180 m to 390 m asl. However, this study was restricted to elevations below 290 m as it was carried out to provide information on the food supply of the White-browed Babbler, which does not occur above this altitude (Taylor 2003). The climate is Mediterranean with hot, dry summers and cool winters.

Quantification of invertebrate abundance

The abundance of leaf litter invertebrates was quantified over a period of two years: the first using Tullgren funnels and the second using hand-sorting in the field.

In the Tullgren funnel extraction, fifteen leaf litter samples were taken every second month from June 1999. Randomly selected co-ordinates determined the location of each sample.

A 0.25 m^2 quadrat, comprising four 50 cm lengths of plywood of height 10 cm, was placed gently to minimise disturbance to the invertebrates. Invertebrates disturbed in the process were gathered into plastic tubes before all the leaf litter within the quadrat was scraped up by hand and placed within sealed bags. Each sample was weighed (± 1 g) in the field using a Pesola balance.

The leaf litter samples were placed in Tullgren funnels for extraction of the invertebrates within one to five hours after collection. The extraction set-up comprised 30 cm long metal cylinders with a grid base of 15 cm diameter. Each sample was extracted separately using as many cylinders as were required to hold the litter loosely. Each cylinder was placed in a plastic funnel leading to a tube containing 80% ethanol for preserving the invertebrates and closed with a lid from which a 60 W globe hung such that it was within 5-10 cm of the leaf litter. Samples were left under the lights for approximately 48 hours to give sufficient time to extract the invertebrates (New 1998).

The dry weight of each leaf litter sample was determined by oven drying a weighed (± 0.01 g) sample at 100°C until constant weight (six to eight hours). The moisture content of the original sample from each quadrat was then determined by subtraction from the wet weight.

The extracted invertebrates were sorted under a binocular microscope. Body length of invertebrates ≥ 1.0 mm was measured to the nearest 0.1 mm using a minigrid. This measure excluded the lengths of any anten-

nae and wings where they extended beyond the head and abdomen. Invertebrates were classified to order except for Collembola, Protura, Chilopoda and Diplopoda that were identified only to class. Invertebrates of body length < 1.0 mm were not identified, but total counts were made.

Invertebrate abundance was determined by hand-sorting for one year from March 2001. Searching by hand is a reliable, basic method for determining invertebrate abundance and is less time consuming than the Tullgren funnel method (New 1998). Sampling was carried out monthly on fine, clear or only partially cloudy days as it was easier to search the sample in sunshine. Fifteen sample quadrats of leaf litter, also 0.5 m x 0.5 m, were taken each month from a 15 ha section in the north of the park. After initial removal of large, conspicuous invertebrates the remaining leaf litter was sorted systematically in a large (50 cm x 40 cm), high-sided white plastic tray. A searching time of 20 seconds per 10 g of leaf litter was used. The time spent sorting had to be sufficient to obtain the majority of invertebrates in the sample and needed to be standardised such that the search effort was constant for samples containing different amounts of litter. To determine the time needed, 25 samples of leaf litter were sorted by hand and the time of capture of each invertebrate was recorded. When sorting leaf litter samples for a duration of 20 seconds per 10 g of leaf litter, 90% of the total number of invertebrates extracted had been found after 70% of the sampling time had passed. This suggested that searching time would have to have been increased considerably to find the remaining invertebrates. With an error of only 5% of biomass this compromise was considered acceptable (see below). Searching was restricted to invertebrates of ≥ 2.0 mm long, which were classified to the level of order and their lengths measured to the nearest 0.1 mm (as above).

To determine the number of invertebrates not collected during the hand-sorting method, and to calibrate hand-sorting with the Tullgren funnel extraction method, the samples for April 2001 were first sorted by hand before remaining invertebrates were extracted using Tullgren funnels: 24.8% of invertebrates ≥ 2.0 mm were not extracted using the hand-sorting method. However, as most of these (57%) were small (< 3.0 mm), the mean percentage of dry mass of invertebrates not extracted from the leaf litter samples using the hand-sorting method was only 5.0% ± 1.2%.

Weekly maximum and minimum temperatures were recorded for one year from the beginning of February 2002. A thermometer was placed in the shade, 2 m above ground level. Rainfall was recorded daily by the rainfall observer at the Chiltern Licensed Post Office located immediately adjacent to the study area.

Analysis

Invertebrate abundance could have been quantified as the density of invertebrates. However, dry mass (biomass) is a better measure of food supply for vertebrates as it takes into account the different sizes of potential prey. Therefore, the dry mass of invertebrates in each sample quadrat was calculated from their lengths using the equation developed by Rogers *et al.* (1976), $W = 0.0305L^{2.62}$, where W is the dry mass in milligrams and L the length in millimetres. The data for dry mass were normally distributed when transformed by $\log(x + 1)$. Analysis of covariance was used to determine seasonal differences in invertebrate biomass with the weight of leaf litter in the sample as a covariate as this also varied seasonally. The moisture content of the leaf litter was expressed as a percentage of the wet weight of the leaf litter. Leaf litter samples collected immediately following rain were excluded from the analyses of seasonal variation in moisture content and the relationship with invertebrate biomass.

Results

Composition of invertebrates in leaf litter samples

The invertebrates collected by both methods were classified into seven arthropod classes: Arachnida, Malacostraca (all Isopoda – woodlice), Chilopoda (centipedes), Diplopoda (millipedes), Insecta, Collembola (springtails) and Protura (proturans). The Arachnida comprised three orders: Araneae (spiders), Acarina (mites) and Pseudoscorpionida (pseudoscorpions);

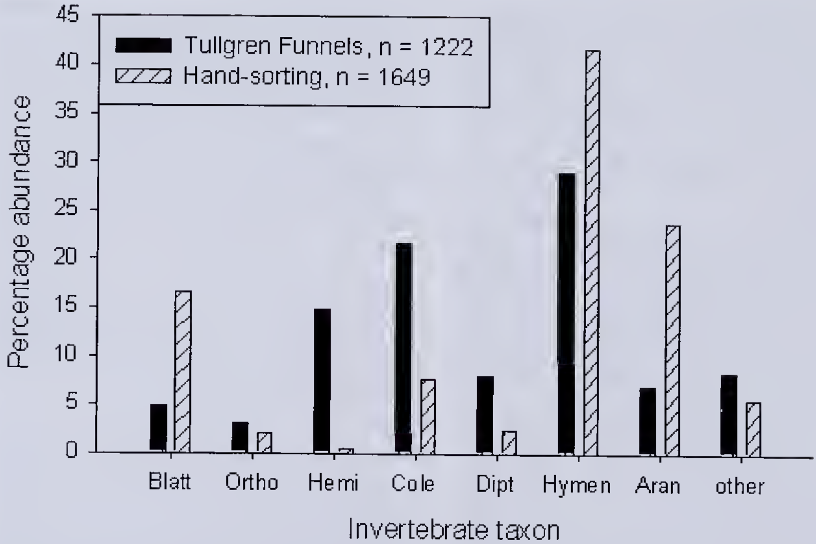

Fig. 1. The percentage abundance (by number) of invertebrates ≥ 2.0 mm by taxon in the leaf litter extracted by the Tullgren funnel method and the hand-sorting method. The taxa are Blattodea, Orthoptera, Hemiptera, Coleoptera, Diptera, Hymenoptera and Araneida. 'Other' includes Collembola, Thysanura, Isoptera, Psocoptera, Thysanoptera, Neuroptera, Lepidoptera, Acarina, Isopoda, Chelinethida, Chilopoda and Diplopoda (all less than 3% each).

and the Insecta 12 orders: Thysanura (silverfish), Blattodea (cockroaches), Isoptera (termites), Orthoptera (grasshoppers and crickets), Psocoptera (psocids), Hemiptera (bugs and leafhoppers), Thysanoptera (thrips), Neuroptera (antlions), Coleoptera (beetles), Diptera (flies), Lepidoptera (moths and butterflies), and Hymenoptera (ants and wasps).

For invertebrates ≥ 1.0 mm long extracted using Tullgren funnels (n = 2 537), Hymenoptera was the most numerous comprising 22% of the total. Of these 97.8% were Formicidae (ants). Collembola (19%) and Coleoptera (19%) were also numerically important, followed by Diptera (11%), Hemiptera (8%) and Araneida, (5%). Remaining taxa each made up less than 3% of the total number. Only 6% of the invertebrates were ≥ 2.0 mm and Hymenoptera was the most numerous (29%, Fig. 1).

Individuals in the four taxa Blattodea, Coleoptera, Hymenoptera and Araneida made up 82% of invertebrates sampled by hand-sorting (n = 1,649, Fig. 1). Hymenoptera was the most numerous (41.7%); all were Formicidae (ants).

Size classes of invertebrates in leaf litter samples

Of the 19 209 invertebrates ≥ 0.1 mm extracted using the Tullgren funnels, 87% were < 1.0 mm. Considering those ≥ 1.0 mm, most (52%) were in the smallest length class of 1.0-1.9 mm (n = 2 537) and 91% were < 5.0 mm.

The frequency distribution of the size classes was similar for invertebrates ≥ 2.0 mm extracted by both methods (Fig. 2). Most, 46% for the Tullgren funnels and 41% for the hand-sorting, were in the smallest length category of 2-2.9 mm while 81% for the Tullgren funnels and 77% for hand-sorting were < 5.0 mm (Fig. 2).

Seasonal variation in the dry mass (biomass) of leaf litter invertebrates

For 1999-2000 (extraction by Tullgren funnels) dry masses were calculated separately for invertebrates ≥ 0.1 mm, and for those ≥ 2.0 mm. Invertebrates < 2.0 mm contributed little to the total dry mass. There was a significant annual variation in the dry mass of leaf litter invertebrates ≥ 2.0 mm body length (ANCOVA with dry weight of leaf litter as a covariate, $F_{(6,84)} = 5.12$, $P < 0.01$, Fig. 3a) with a short peak

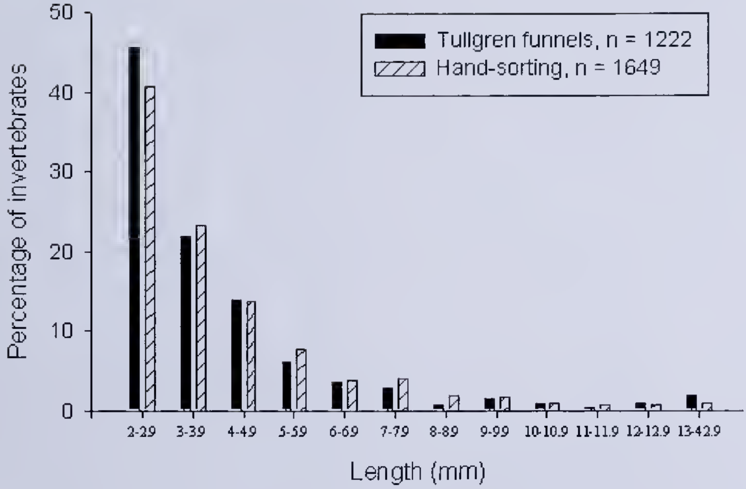

Fig. 2. Frequency distributions of the length classes of invertebrates ≥ 2.0 mm extracted by the Tullgren funnel and hand-sorting methods.

of about two months' duration from the end of winter (late August), and the lowest value was in summer (late December).

For 2001-2002 (hand-sorting) the same general pattern was shown (ANCOVA with wet weight of leaf litter as a covariate, $F_{(12,132)} = 10.06$, $P < 0.001$, Fig. 3b) with a peak in dry mass at the end of winter (late August), and the lowest values during summer (November –February). Values were also low in late autumn (late May).

Moisture content of leaf litter

There was a significant annual variation in the moisture content of the leaf litter (ANOVA of percentage of wet weight (arcsine transformed), $F_{(4,58)} = 6.50$, $P < 0.001$, Fig. 4) which followed a similar pattern as the variation in invertebrate biomass, being highest at the end of winter (late August) and lowest in summer (December). The mean dry mass of invertebrates was significantly correlated with the moisture content of the leaf litter ($r = 0.93$, $P = 0.02$, $N = 5$, Fig. 5).

Temperature and rainfall

In the year from February 2001, weekly minimum temperatures ranged from 0-18°C and maximum temperatures ranged from 11-40°C. Temperatures were highest from December to March and lowest from June to July.

From 1984 to 2002, annual rainfall varied from 418.4 mm to 1039.0 mm with a mean of 720.9 ± 33.5 mm. From 1999 to 2002 monthly rainfall was highly variable (0.0 mm – 124.6 mm), but generally winter months had more rainfall than summer months. During the two years of the invertebrate sampling, winter rainfall was 206.8 mm and 120.0 mm and summer rainfall was 169.4 mm and 109.6 mm, respectively.

Discussion

The compostition of leaf litter invertebrates in the present study can be compared with an investigation of the diversity of ground-dwelling invertebrates using pitfall traps at 80 sites (including the present site) across the box-ironbark region in Victoria (Yen *et al.* 1999). In both studies Hymenoptera was the most numerous taxon and for invertebrates extracted using the Tullgren funnels, Coleoptera, Diptera, Hemiptera and Araneida followed in the same order of percentage abundance in both studies, but Collembola were also numerically important in the present study. In the hand-sorting method Blattodea also had a high relative abundance. These differences are likely to have arisen from the different sampling methods used. Pitfall traps are not reliable for measuring absolute abundance as the composition of the catch is influenced by the susceptibility

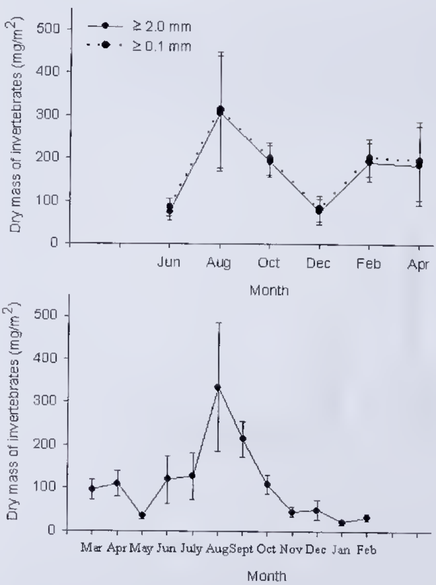

Fig. 3. The annual variation in the mean dry mass of leaf litter invertebrates (± 1 S.E.) during two years: a) June 1999 to April 2000 obtained using the Tullgren funnel method and b) March 2001 to February 2002 obtained using the hand-sorting method. For both years the dry mass of invertebrates ≥ 2.0 mm body length is shown and for 1999-2000 the dry mass of all invertebrates ≥ 0.1 mm body length is also shown.

of different types of invertebrates to trapping (Greenslade 1964, Bromham *et al.* 1999). The Tullgren funnel method of extraction might give a more accurate representation of invertebrate community composition, but the efficiency of extraction of invertebrates varies among taxa (Macfadyen 1961, Southwood 1966) whereas hand-sorting has been reported to be particularly useful in recovering invertebrates with low mobility (New 1998), but might be biased towards less cryptic species.

In this study there was a significant seasonal variation in the biomass of the leaf litter invertebrates, with a peak of one to two months' duration from the end of winter, the coolest and wettest period of the year and lowest biomass during the summer, the hottest and driest period.

There are no other published studies of seasonal changes in leaf litter invertebrates in box-ironbark forests and few in other forest types. Leaf litter arthropods had a two to three month peak in biomass during autumn in eucalypt forest in central New South Wales (Ford *et al.* 1990), and in Mountain Ash *E. regnans* forests of Victoria, leaf litter invertebrates were more abundant during winter than summer (Ashton 1975 cited in Loyn 1985). Autumn or winter peaks in abundance,

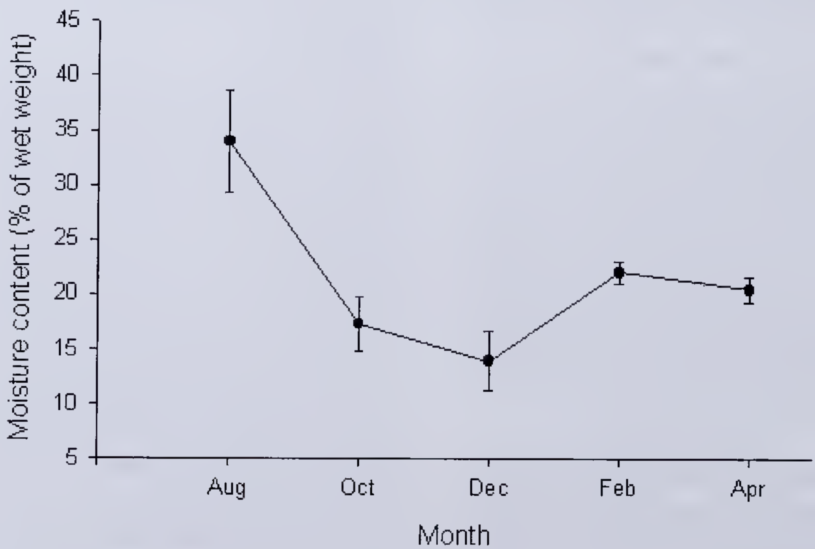

Fig. 4. The annual variation in the moisture content of leaf litter (± 1 S.E.), expressed as the percentage of wet weight of leaf litter, from August 1999 to April 2000.

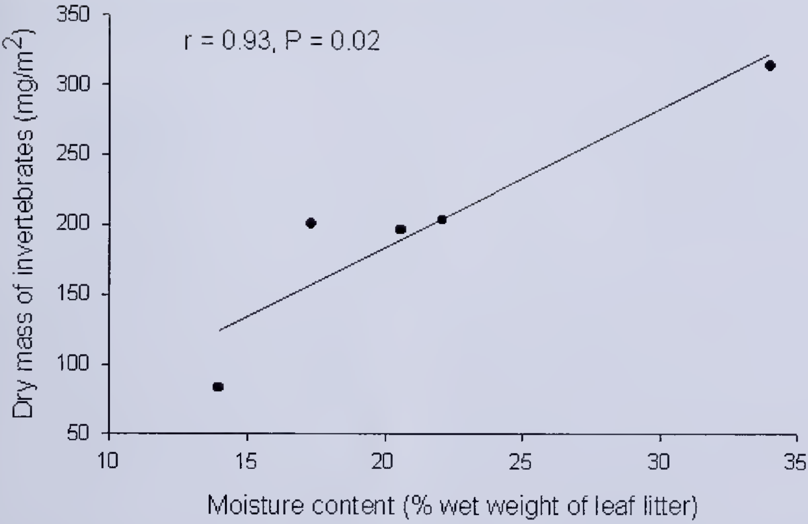

Fig. 5. The variation in the dry weight of leaf litter invertebrates in relation to the moisture content of the leaf litter.

when the leaf litter is relatively moist, and summer lows when conditions are driest, may therefore be a general phenomenon in forests of southern Australia. A summer peak in numbers of ground macroinvertebrates in Grey Box woodland around Benalla, Victoria (Bromham *et al.* 1999) may have reflected invertebrate activity on the surface rather than abundance within leaf litter as pitfall traps were used.

In the present study there was significant seasonal variation in the moisture content of the leaf litter, and invertebrate biomass was significantly correlated with moisture content. In tropical forests of Australia, leaf litter moisture content and arthropod abundance were higher in the wet than in the dry season (Jansen 1997). In Panama abundance was significantly correlated with the moisture content of the litter (Levings and Windsor 1982) and significant increases were recorded on experimentally watered plots (Levings and Windsor 1984). Wet tropical forests in Australia had higher leaf litter invertebrate densities than did dry tropical forests (Plowman 1979). Seasonal and regional variations in the moisture content of leaf litter are therefore probably main factors determining leaf litter arthropod abundance.

The low densities and small sizes of most invertebrates recorded in the present study might suggest that the box-ironbark forest of the study area was a poor quality habitat for ground-feeding insectivorous vertebrates. Direct comparisons with other forests in Australia are difficult as most studies have compared only the relative abundance of selected taxa (Frith and Frith 1990; Bromham *et al.* 1999, Yen *et al.* 1999). Where the absolute abundance (density) has been quantified, biomass has not been calculated. The Berlese funnel extraction technique, comparable to the extraction with Tullgren funnels used in this study, has been used to quantify the density of all invertebrates in several forest types (Table 1). In these studies, the densities of invertebrates were greater than those recorded in the present study, and in most the values were very considerably higher. These comparisons probably represent real differences in densities, but might have been influenced by the size ranges of invertebrates quantified. Lengths below the lower limit of 0.1 mm used in this study might have been included, but details were not provided except in the studies of Jansen (1993, 1997) and that of Cale (1999) in which a hand-sorting method

Table 1. The density of invertebrates extracted from leaf litter from different forest types in Australia using Berlese or Tullgren funnels. Ranges indicate the variation in density recorded in different seasons or sites.

Forest type/location	Density (per m^2)	Author
Nothofagus, Victoria	847-2821	Howard 1975
Nothofagus, Tasmania	2022-3421	Howard 1975
Nothofagus, New South Wales	7868	Plowman 1979
Rainforest, Queensland	3210-115,470	Plowman 1979
Rainforest, Queensland	500-600	Jansen 1993
Rainforest, Queensland	260-640	Jansen 1997
Wet sclerophyll, Queensland	8050-105,940	Plowman 1979
Casuarina/Eucalyptus, New South Wales	14,887	Plowman 1979
Box-Ironbark, Victoria	116-255	This study

was employed allowing comparison with the present study. The density of invertebrates > 2 mm long varied with season and site from 52-144 per m^2 in rainforest in Queensland (Jansen 1997) compared with a seasonal variation of 27-91 per m^2 in the present study. In addition, there was a higher proportion of larger sized invertebrates in Queensland with 45% > 1 mm long compared with 13% in the present study, indicating that the dry mass of invertebrates was also considerably greater in the rainforests sites. Invertebrates ≥ 3 mm long were quantified in spring and summer in broad leaf litter in *Allocasuarina/Eucalyptus* woodland in Western Australia (Noack 1996 cited in Cale 1999). The densities were higher than in the present study with 36.3 per m^2 compared with 17.9 per m^2 in spring, and 9.3 per m^2 compared with 5.2 per m^2 in summer. However, both studies were relatively short-term and making comparisons of invertebrate densities from such limited time periods in areas where large variations in climatic factors such as rainfall could have a large effect may be misleading.

The information from within Australia suggests that leaf litter in box-ironbark forest supports relatively low densities of invertebrate prey for insectivorous birds such as the White-browed Babbler. Densities may also be low compared with forests outside Australia. Leaf litter invertebrate biomass in areas of Tennessee occupied by Ovenbirds *Seiurus aurocapillus*, a warbler that forages on leaf litter invertebrates (Smith and Shugart 1987), was 14 times greater than that in box-ironbark forest during the White-browed Babblers' breeding season in the present study. It was also six times greater than the peak invertebrate biomass recorded at Chiltern. Areas, which were judged to be unsuitable Ovenbird habitat because of low invertebrate density, still had a mean invertebrate biomass eight times greater than that in the box-ironbark leaf litter. In a second study in Ontario (Zach and Falls 1979), areas of deciduous forest avoided by Ovenbirds had invertebrate biomasses approximately equivalent to those in areas used by breeding White-browed Babblers in this study.

Direct comparisons are also possible with a study of Swainson's Warblers *Limnothlypis swainsonii*, another leaf litter forager, wintering in Jamaica (Strong and Sherry 2001). Invertebrate biomass in secondary forest leaf litter, a habitat considered marginal for the species as birds were unable to increase body mass before migration, was equivalent to the highest biomass recorded in this study during late winter and early spring. Thus, during the main period of the year, when White-browed Babblers attempt to breed, box-ironbark forest supported a biomass of leaf litter invertebrates that was equivalent to that judged to be adequate only for daily maintenance of non-breeding Swainson's Warblers.

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The Brown Toadlet *Pseudophryne bibronii*: a story of survival

The Brown Toadlet *Pseudophryne bibronii* (also known as Bibron's Toadlet) is a small, secretive frog that inhabits grassland, woodlands and dry forest over a wide area of north-eastern, central and western Victoria. Males of the species call from depressions or low-lying areas during and after rain from February to June. The call is a short, grating 'cre-ek' uttered every few seconds (Hero *et al.* 1991).

The Brown Toadlet is one of a number of species that relies on autumn rain for breeding. However, over recent years, with a marked reduction in rainfall, records for the species have declined significantly and the Brown Toadlet is now considered vulnerable in Victoria.

Between April 2000 and March 2002, the Fauna Survey Group of the FNCV conducted a survey of vertebrate fauna of the Black Range, near Stawell in western Victoria (Homan 2005). On the first visit to the district the group camped at the Stawell Park Caravan Park, beside Pleasant Creek, about five kilometres south of Stawell. Many of the people who attended that first trip had recently completed a frog identification course. We were therefore very keen to put newly acquired frog-finding skills into practice and so at night we searched for frogs along the creek and in nearby paddocks and woodland. Directly over the creek from the caravan park was a low-lying paddock, with thick grass and several depressions, perfect habitat for the Brown Toadlet. The paddock was also adjacent to a wide roadside verge of remnant woodland.

As we crossed the creek we could hear male toadlets calling from the depressions in the paddock, and after much effort, we succeeded in locating and capturing several. Some of us were familiar with the species from club trips to Rushworth Forest, but for most members it was the first time they had heard or seen the Brown Toadlet.

Since the Black Range survey finished early in 2002, the Stawell district has been in the grip of severe drought and, whilst I have visited the district many times since, none of my visits coincided with rain, especially during autumn. However, I had arranged to visit friends in Stawell on the last weekend in April 2007 and, luckily, substantial rain fell across the district on the Friday and Saturday. My partner, Maryrose Morgan, and I arrived in Stawell late in the afternoon of Sunday 29 April 2007, to find wet roads and roadside puddles. Shortly after dark we drove down the track to Pleasant Creek and walked the 20 m through the woodland roadside verge to the paddock where we had found Brown Toadlets exactly seven years previously.

We stood motionless beside the boundary fence and scanned the paddock with torches and waited in the dark hoping to hear toadlets calling. However, the drought had taken a heavy toll and the once lush paddock was now almost bare dirt, with virtually no grass cover at all – not good habitat for the Brown Toadlet. We were about to leave when, directly behind us from within the roadside verge, came the grating 'cre-ek' of a male Brown Toadlet. Very soon another toadlet called from further along the verge and then another. Each one was calling from wet depressions filled with a thick layer of leaves, bark and twigs tangled amongst Finger Rush *Juncus subsecundus* in the remnant woodland.

In recent years there has been much bad news concerning declining frog populations around the world. It is therefore very pleasing to know that, despite one of the most severe droughts on record, at least one population of a wonderful little toadlet has survived in western Victoria. The experience also reinforced the value of roadside verges, which often provide important remnant habitat, particularly in agricultural districts.

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Agates: Treasures of the Earth

by Roger Pabian, with Brian Jackson, Peter Tandy and John Cromartie

Publisher: *The Natural History Museum, London, 2006, 192 pages, hardback; colour photographs. ISBN 0643092978. RRP $54.95*

This new book in the Earth Series from the Natural History Museum is an extremely comprehensive, beautifully produced and illustrated book. It will surely find its way into the geological and gemstone sections of most libraries and into the personal collections of those with specialist interests in mineralogy and lapidary. The book is the latest in a series of titles that includes *Diamonds*; *Gemstones*; *Crystals*; *Gold*; and *Amber*.

The book is divided into a general discussion of agates, their naming, definition and properties, history, a larger section on the worldwide distribution and finally concluding with a section on Lapidary and the uses of agate.

Roger Pabian, the principal author, is a recently-retired agate specialist and palaeontologist from the University of Nebraska-Lincoln. His co-authors come from a variety of backgrounds but all are agate specialists. They have combined to produce a book that provides a stimulating introduction to these fascinating gemstones, whilst meeting the requirements of a number of potential audiences, both professional and amateur as well as the casual reader.

For those with the grounding in geology, the technical discussion of the complexities of agate mineralogy will be informative and interesting, agate being formed by a series of very interesting geochemical processes that are clearly explained. For the wider audience, this section may appear to be too technical, but the explanations are clear and accessible. The discussion on the history, colours, occurrence, classification, and worldwide distribution of agates is of interest to both the professional and anyone interested in the beauty of this widely-distributed and historically famous mineral. It is a book that would particularly appeal to those with an interest in lapidary as a hobby, and casual collectors of minerals and rocks, including as it does an introduction to the preparation and presentation of agates as either specimens or as a jewellery stone.

More than 100 pages are devoted to sources of agates around the world, with the agate varieties described and illustrated from the various continents and a number of countries. The photographs of wonderful examples from each source area are incredibly beautiful and will appeal to all those who open this book, even the most casual reader. The origins, ages, types, and uniqueness of agates and the history of each agate field makes interesting reading. However, being a book that attempts to provide world coverage of agates and their distribution, it is of necessity not hugely detailed on each agate source. Consequently, if one were particularly interested in collecting Australian agates, this book would provide only a starting point in the quest of acquiring these appealing gemstones.

The book is well worth searching out if you have an interest in geology, mineralogy, gemstones, lapidary or even the art of natural photography. *Agates: Treasures of the Earth* is a worthy addition to this Natural History Museum series.

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Practical Conservation Biology

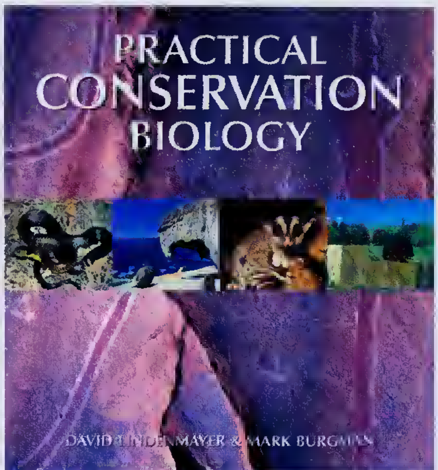
by David Lindenmayer and Mark Burgman

Publisher: *CSIRO Publishing, Collingwood, 2005. 624 pages, paperback; ISBN 0643090894. RRP $79.95*

Mention the subject 'conservation biology' and the names of two of the best practitioners — David Lindenmayer and Mark Burgman — spring to mind . As the title of their new book suggests, this work focuses on 'how to do practical conservation biology'. Much of the book is aimed at an Australian audience, making use of examples from this country. The authors chose to take an Australian perspective for two reasons. The first reason was that there are few texts that deal adequately with the conservation of the Australian environment. The second reason lay with the uniqueness of the Australian continent and its resources.

The book has been structured in such a way that it can be read either from start to finish, or by dipping into selected sections of interest. It is divided into four broad sections: (1) principles for conservation; (2) impacts; (3) methods of analysis; and (4) management principles for conservation. The first two sections deal with general principles and are thus appropriate for introductory studies. Topics covered in these sections include: Why conserve? What should be conserved? Conservation status; changes in the physical environment; genetic diversity; harvesting natural populations; habitat loss and fragmentation; and demands of the human population. The concepts are both explained and illustrated, using a wide range of current, relevant Australian examples from published sources. Use of local examples here really helps the Australian student or practitioner relate to the text.

The last two sections of the book present more advanced information. The third section delves into methods of analysis for conservation biology. This will be of relevance to those people using analytical methods to solve problems in conservation biology. The topics covered here include: measuring genetic variation; habitat analysis; reserve design; bioclimatic modelling; measuring diversity; monitoring; statistical power;



indicators; and risk assessment. The final section of the book examines some general themes in conservation biology, particularly as they relate to ecologically sustainable development. The chapter builds up general arguments for conservation and provides a rationale for the focus on sound scientific practices in conservation biology.

Lindenmayer and Burgman have produced an exemplary text for both students and practitioners in the local context. The book's exploration of modern conservation biology is supported throughout by numerous case studies, with a focus that is predominantly Australian. That said, the methods and lessons from the case studies are widely relevant and can be usefully compared and applied to conservation studies elsewhere. My only concern about the book is that the text is aimed at the advanced undergraduate, and may not be appropriate for first year students. The methods that are introduced for detecting and solving conservation problems assume familiarly with basic knowledge of conservation concepts and practical statistics.

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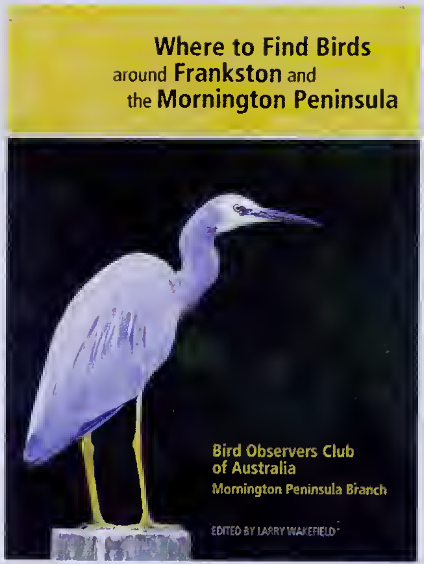
Where to Find Birds around Frankston and the Mornington Peninsula

edited by Larry Wakefield

Publisher: *Bird Observers Club of Australia, Mornington Peninsula Branch, 2006. 79 pages, paperback; BOCA Report no. 15. ISSN 1321-3318. RRP $24.95*



In 2005, the Bird Observers Club of Australia (now Bird Observation & Conservation Australia) celebrated its centenary year. To mark this occasion, the Mornington Peninsula Branch of the Club (PENBOC) decided to produce a bird locality guide for the Mornington Peninsula, Victoria, for use by visitors, residents and all bird-watchers, whether novice or experienced. This project was successfully completed in December 2006.

It is clear that much careful thought has gone into producing this book. It is attractively presented, with one painting and 75 photographs of birds sprinkled through the informative text. A short introduction is followed by a large clear map showing 22 birding localities, 10 of which are labelled as outstanding. This is followed by 'Habitats and Bird Assemblages', in which seven types of habitat are described and accompanied by lists of birds likely to be present. Habitat types are colour-coded throughout the book; for example, if the text is on a blue background, you are looking at 'wetlands' information.

The main part of the book describes the localities. These are grouped according to habitat type, starting with the 'forest-woodland' sites. For each locality, a section of the relevant Melway map, along with map number, notes about access, facilities available, and the name and telephone number of the Reserve Manager are supplied, together with a description of the reserve or park and the walking track, and the names of birds to watch out for. Three tours, each taking in three or four of the localities – including at least two outstanding ones – are suggested.

Other topics covered include recent bird arrivals, threatened birds, bird-watching tips, and responsible bird-watching. Contact information for bird-watching organisations and parks and reserves management is supplied on the back cover. There is a comprehensive bird list of 213 (not 214 as stated) regulars and 86 vagrants. Alarmingly, little more than a third of the regulars are listed as common, and even some of those are said to be vulnerable. As many as four species may already be extinct in the area.

Only a few of the photos bear the photographer's name. Although acknowledgements are made, it would have been better to include the photographer's name on each photo. It should also be mentioned that the Department of Sustainability and Environment's 'Victorian Bird Atlas' referred to in this book is actually the database Atlas of Victorian Wildlife.

Hopefully, this book will increase awareness of the value of birds, and encourage preservation and restoration of their habitats. Congratulations to PENBOC for producing such an appealing, compact and useful birding guide. It is a pleasure to recommend this book to all who visit the Mornington Peninsula.

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